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Why Doesn't That Traffic Signal Ever Turn Green? An Evaluation of Roadway Markings for Cyclists

Stefan W. Bussey

Portland State University, stbussey@yahoo.com

Christopher Monsere

Portland State University, monsere@pdx.edu

Peter Koonce

Portland Bureau of Transportation

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Why Doesn't That Traffic Signal Ever Turn Green?

An evaluation of roadway markings for cyclists

Presenter: Stefan Bussey

Coauthors: Dr. Christopher M. Monsere, Portland State University

Peter Koonce, Portland Bureau of Transportation

Portland State University Transportation Seminar

November 8, 2013



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Presentation Overview

- The Basics of Vehicle Detection
- Issues Related to Detection and Bicycles
- History of the Stencil and Sign
- Research Question
- Existing Research
- Study Design
- Results





Where would you wait if driving a car? How about if riding a bike?



Image source: google street view

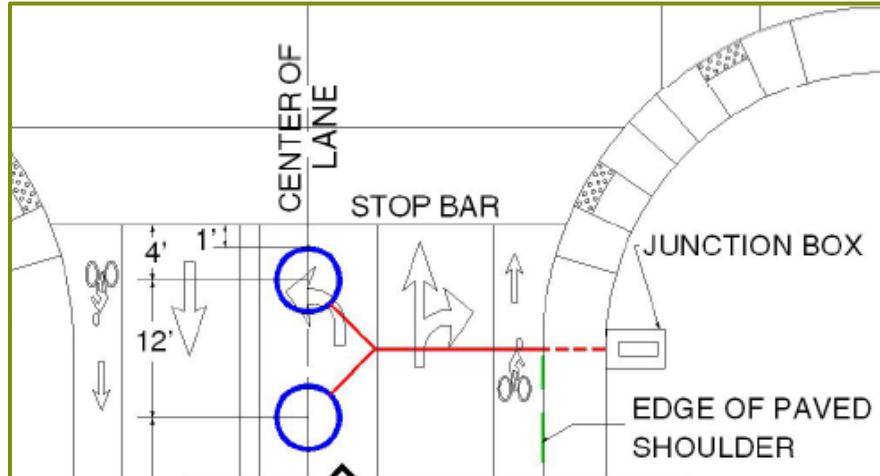


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How Signalized Intersections with Detection Work



(a) Schematic design of loop detector design



(b) Physical representation of loop detectors

Inductive Loop Detectors and Bicycles

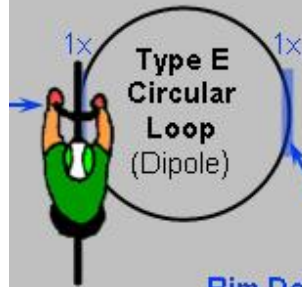


Bicycle Detection

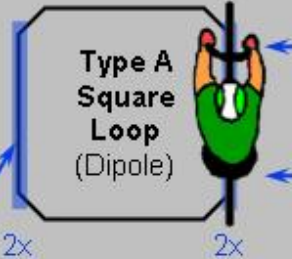


Detection Positions

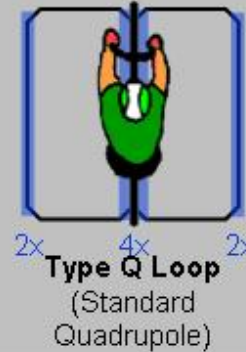
Poor Detector
(one rim = 1x)



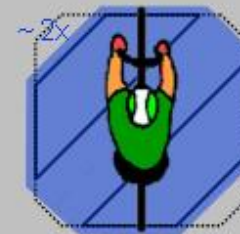
OK Detector
(two rims = 2x)



Better Detection
(narrow 4x & 2x strips)

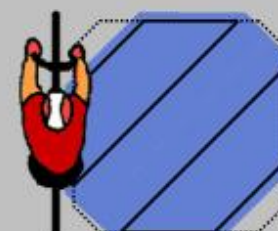
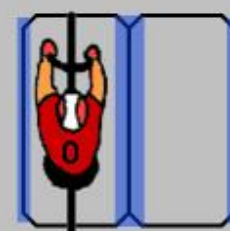
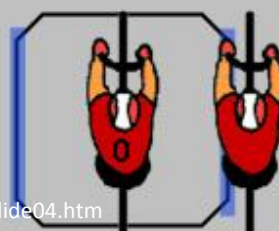


Best Detection
(broad + uniform ~ 2x)



Rim Detection Areas
AKA "Sweet Spots"

Undetectable Positions



source:
www.cyclistview.com/signal/detection/slide04.htm

1/28/2008

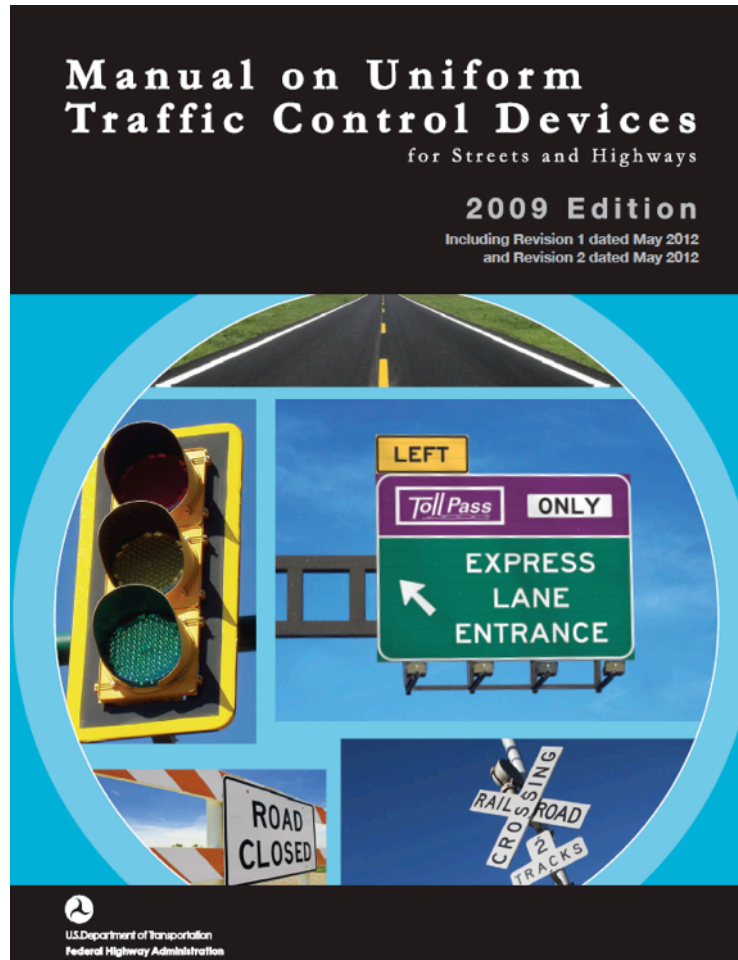
Copyright © 2004 - 2008 www.DualChase.com

Signal Loops - R1.0 - Slide # 4



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Current Marking and Sign for Loop Detectors



9C-05 Bicycle Detector Symbol



R10-22 Sign

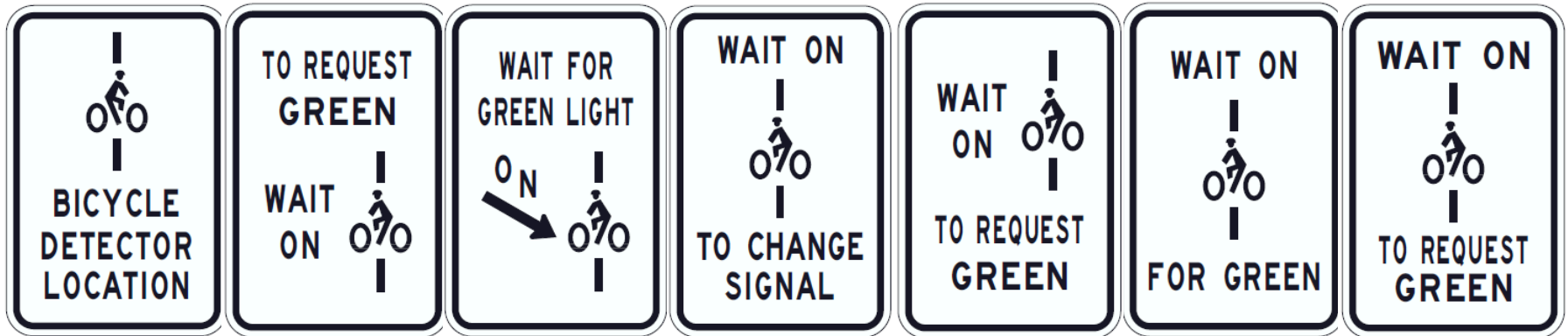


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History of Sign and Stencil

Sources: Richard Moeur and Ron Van Houten

Human Factors Research for R10-22 Sign

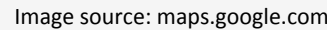


- No research found on roadway marking
- Both first recommended for use in the 1999 AASHTO's guide for roadway design
- Adopted into the 2003 edition of the MUTCD
- No formal experimentation was required



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Are the existing marking techniques specified in the MUTCD effective and is there a more effective alternative?



Existing Research

Boot, Walter, Neil Charness, Cary Stothart, Mark Fox, Ainsley Mitchum, Heather Lupton and Rebekah Landbeck. *Final Report: Aging Road User, Bicyclist, and Pedestrian Safety: Effective Bicycle Signs and Preventing Left-Turn Crashes BDK83 977-15*. Prepared for the Florida Department of Transportation, September 2012

- No correct responses on the meaning of the bicycle detector symbol
- 68 participants
 - 20 cyclists (Identified as a cyclist if reported riding more than 5 miles per week)
 - 48 non-cyclists



Study Design

- In-Person and On-line Survey of Cyclists
- Observational Data Recorded by Cameras Before and After Markings Applied
- Three Test Cases



Case 1: Stencil Only



Case 2: Stencil and Sign



Case 3: "Green Backed" Stencil



Survey – Data Collection

- 227 Complete Responses
 - 81 in person, 94.2% response rate
 - 13.6% did not meet requirements to participate
 - 146 on-line, 16.1% response rate
- Distribution
 - High-density bike parking (on-line)
 - Portland Timbers games (on-line)
 - Providence Bridge Pedal (on-line)
 - Sunday Parkways (in person and on-line)
 - Portland's Downtown Farmers' Market (in person)
- An average of 4 minutes to complete

In Person



On-line

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Please Help Us Better Understand How
Intersection Design Affects Cyclists' Behavior


This survey is part of a study on how intersection design influences cyclists' behavior. The study is being conducted by an undergraduate Civil Engineering student at PSU. The survey takes about 2 minutes to complete. Your help is greatly appreciated.


Survey link: <http://is.gd/psbike>

QR Code for handheld devices (survey may not display correctly for some devices.)



For more information contact
Stefan Bussey at
stbussey@pdx.edu



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We are asking for your help with a study to understand how intersection design affects cyclists' behavior. The project is being carried out by Portland State University (PSU).

The survey should only take 1-2 minutes to complete. You don't have to participate, and you can skip any questions you don't want to answer. Your responses will be completely confidential, and it won't be possible to tell who said what in any reports. If you have any questions about the study, please contact Stefan Bussey (stbussey@pdx.edu).

This study has been reviewed and approved by PSU's Human Subjects Research Review Committee, and if you have any questions about your rights as a participant in this study, you may contact the Office of Research and Strategic Partnerships, Market Center Building Suite 620, Portland State University, (503) 725-4268.

This research can only be successful with the generous help of people like you. We hope you will enjoy the questionnaire and look forward to receiving your responses.

Do you agree to participate in the study?

☐ Yes

☐ No



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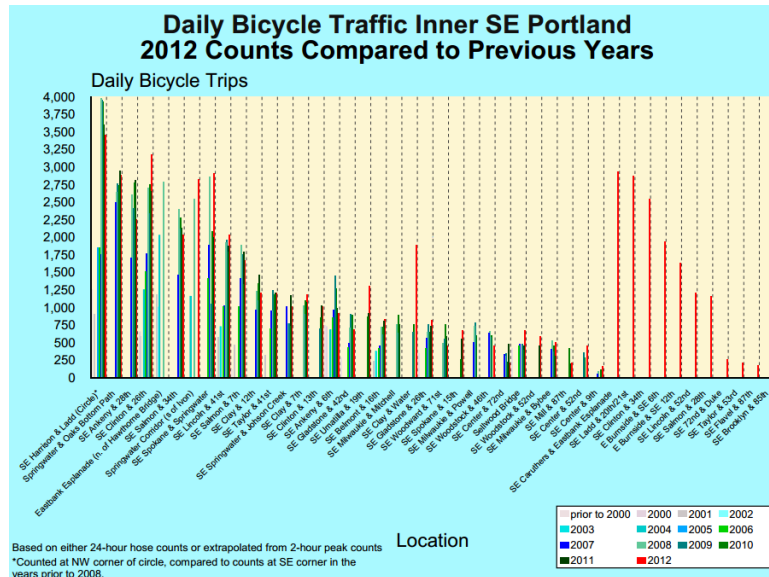
Survey – Questions



- Demographic Information
- Stopping Position at Signalized Intersections (Randomly selected marking variation)
- Reason for Choosing Stopping Position
- Interpretation of Detector Symbol
- Interpretation of Blue Indicator Light (Research in Progress)

Video – Data Collection

- 302 hours of video recorded and reviewed
- 955 observations logged
 - 688 used in analysis
- Only questioned once by the police



- Site Selection
 - No existing marking or signage
 - Visible loops
 - Semi actuated signal operation
 - Similar geometry and lane configurations
 - Popular bike route
- Collection Period
 - Sunday – Tuesday
 - 5:00 AM – 11:00 PM



Video – Data Collection



Dekum and MLK



Ainsworth and MLK

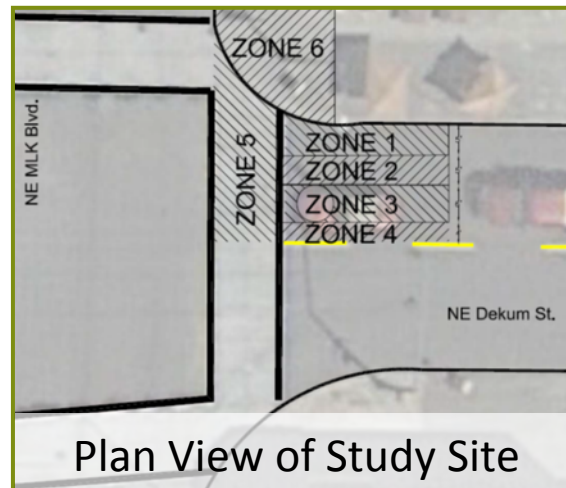


33rd and Grant

Variable	NE Dekum St. and NE MLK Blvd.- WB Approach	NE Ainsworth and NE MLK Blvd. - EB Approach	NE U.S. Grant Place and NE 33 rd Ave, WB Approach
Lane Width (ft)	20	14	20
Number of Travel Lanes	1	1	1
Movements Allowed	Thru, Left, Right	Thru, Left, Right	Thru, Left Right
Loop Type	6' Diameter Circle	6' Diameter Circle	6' Diameter Circle
Distance from Curb to Edge of Loop (ft)	10	4	10

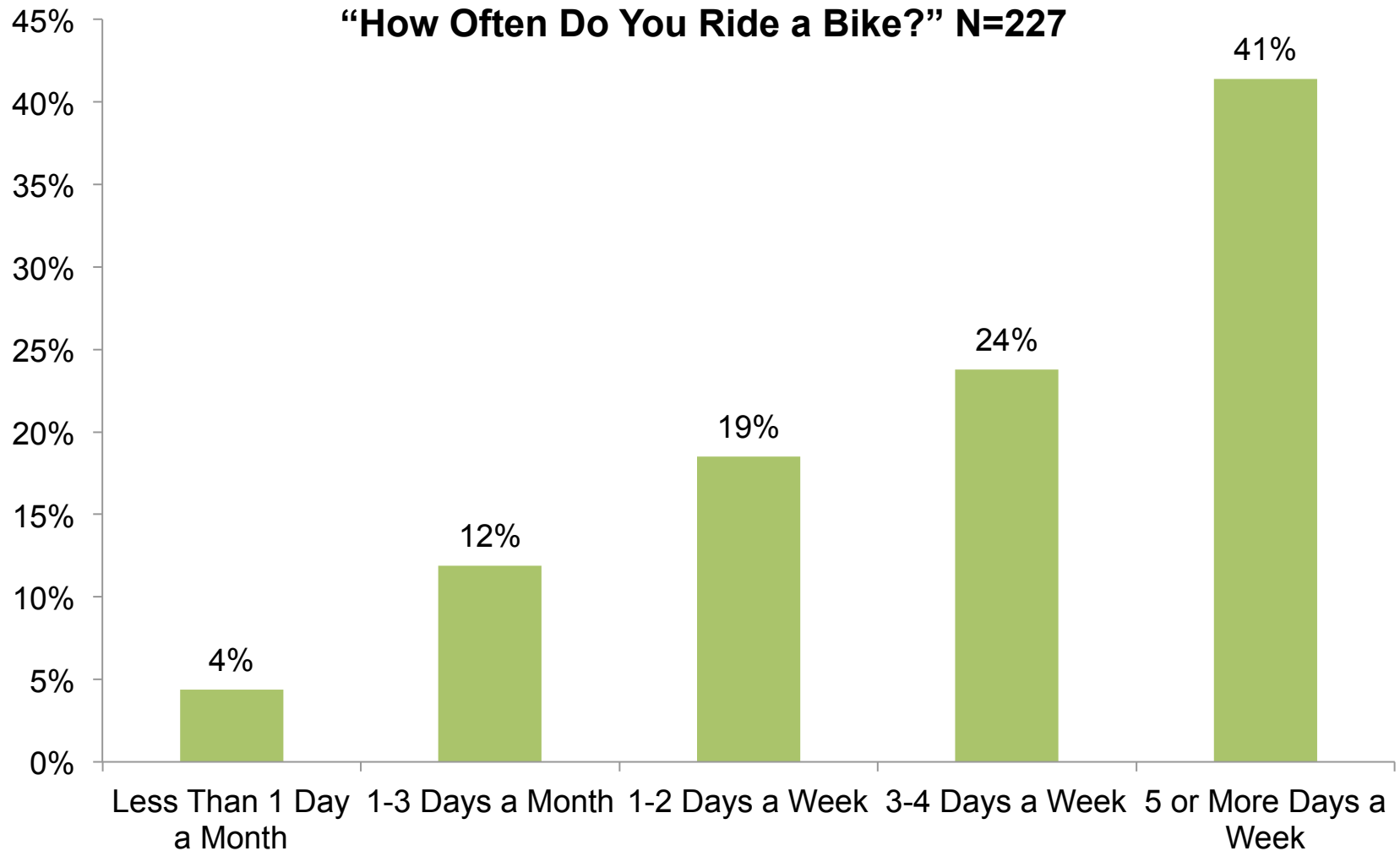


Video – Data Collection

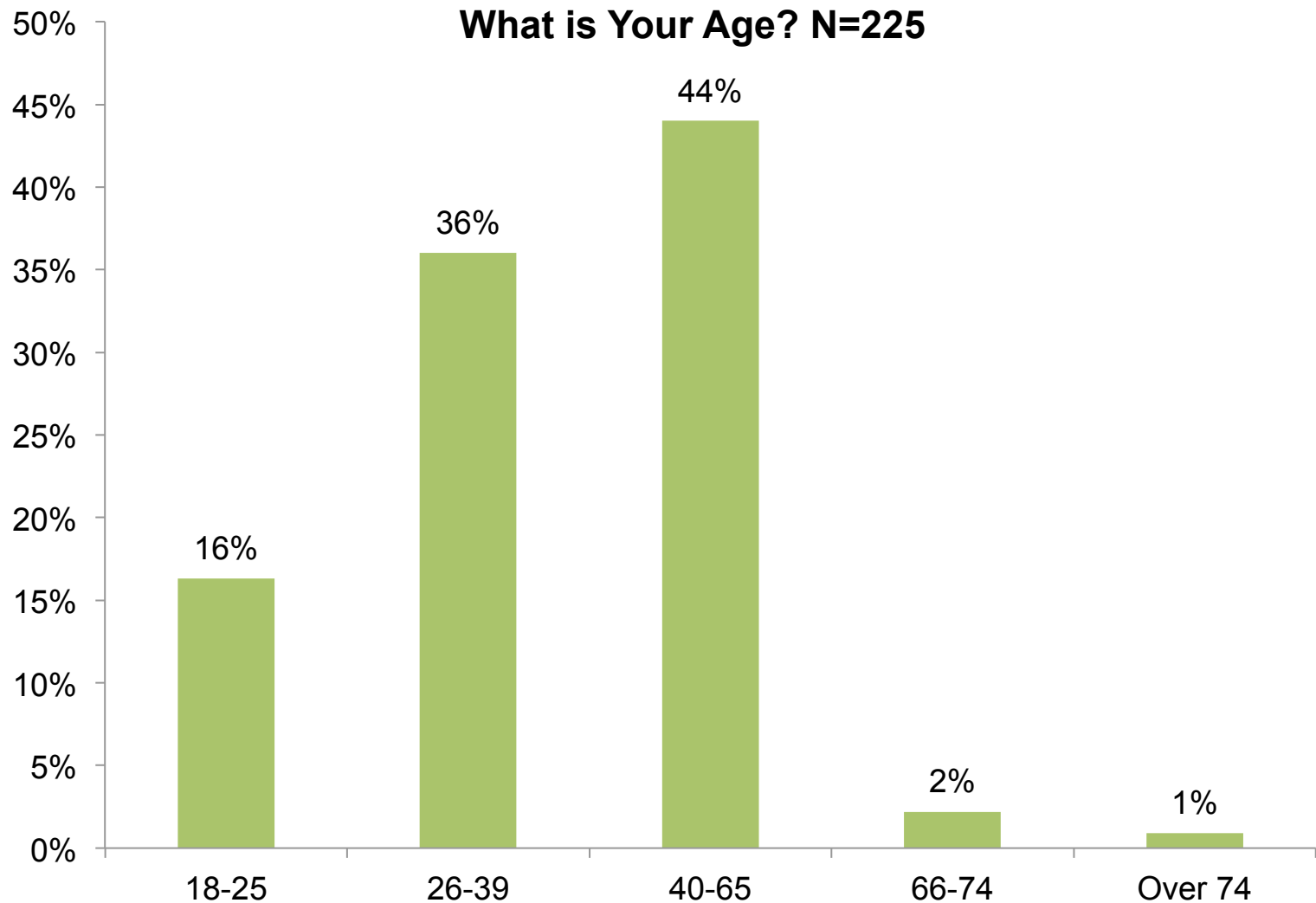


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Survey – Results

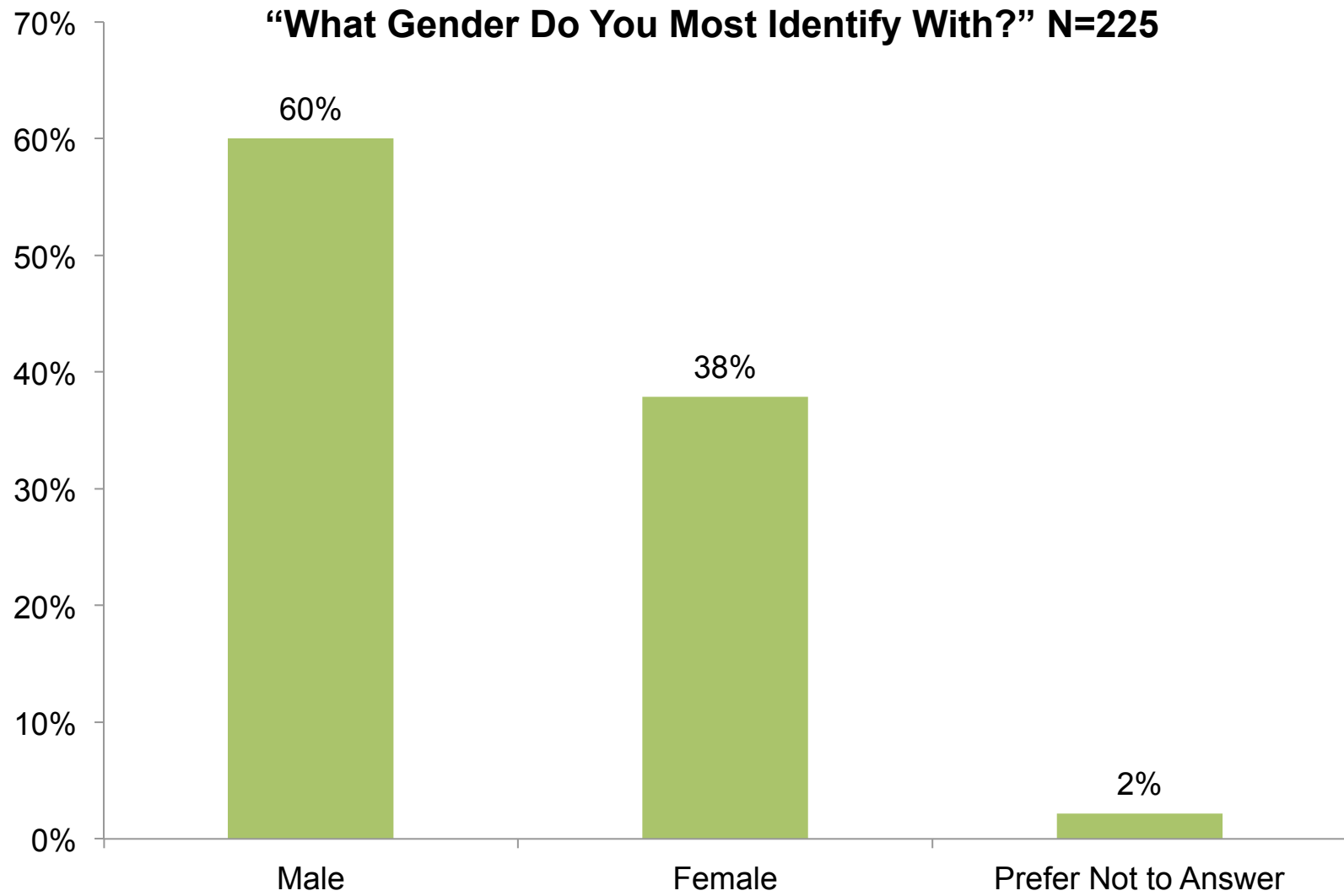


Survey – Results



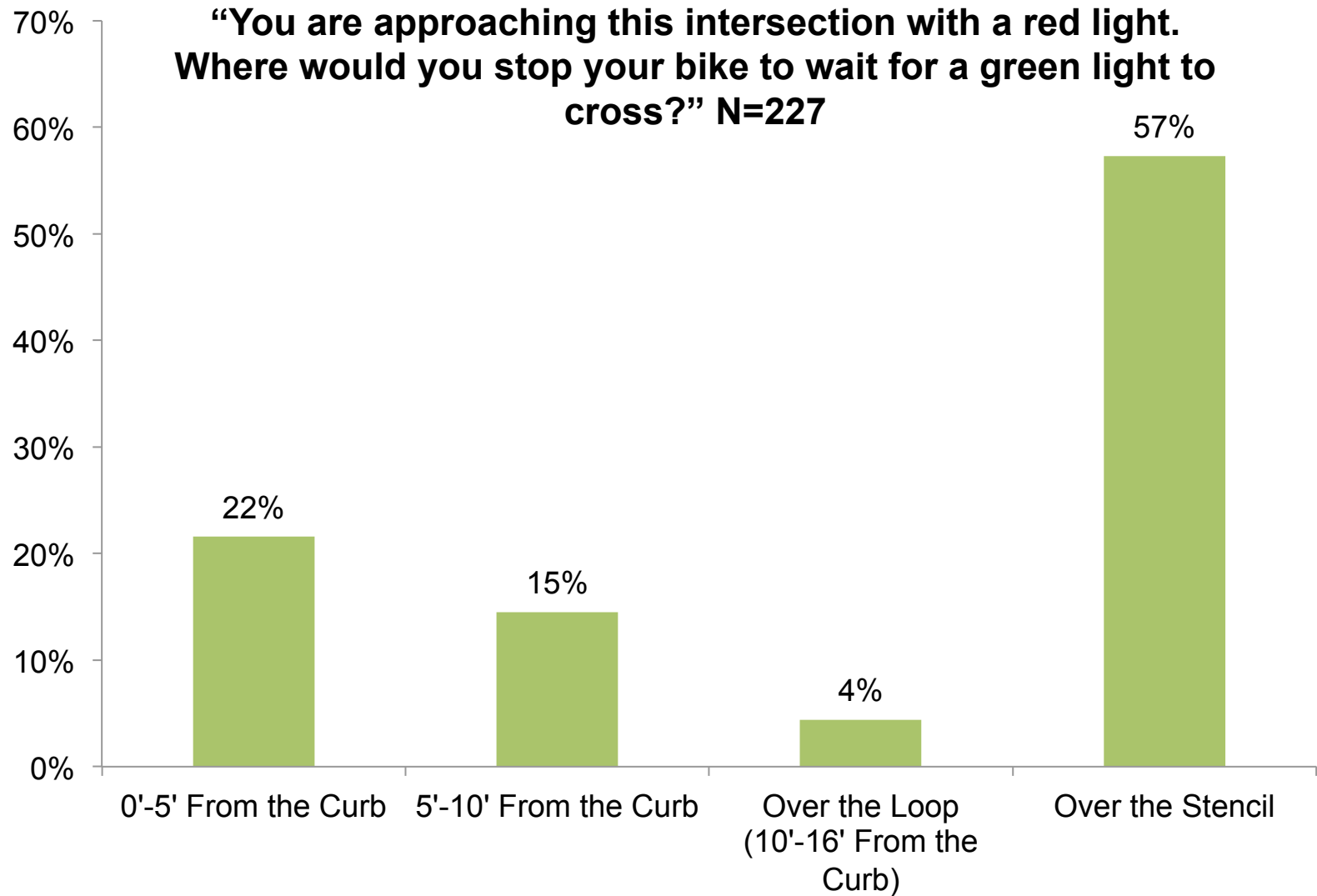
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Survey – Results

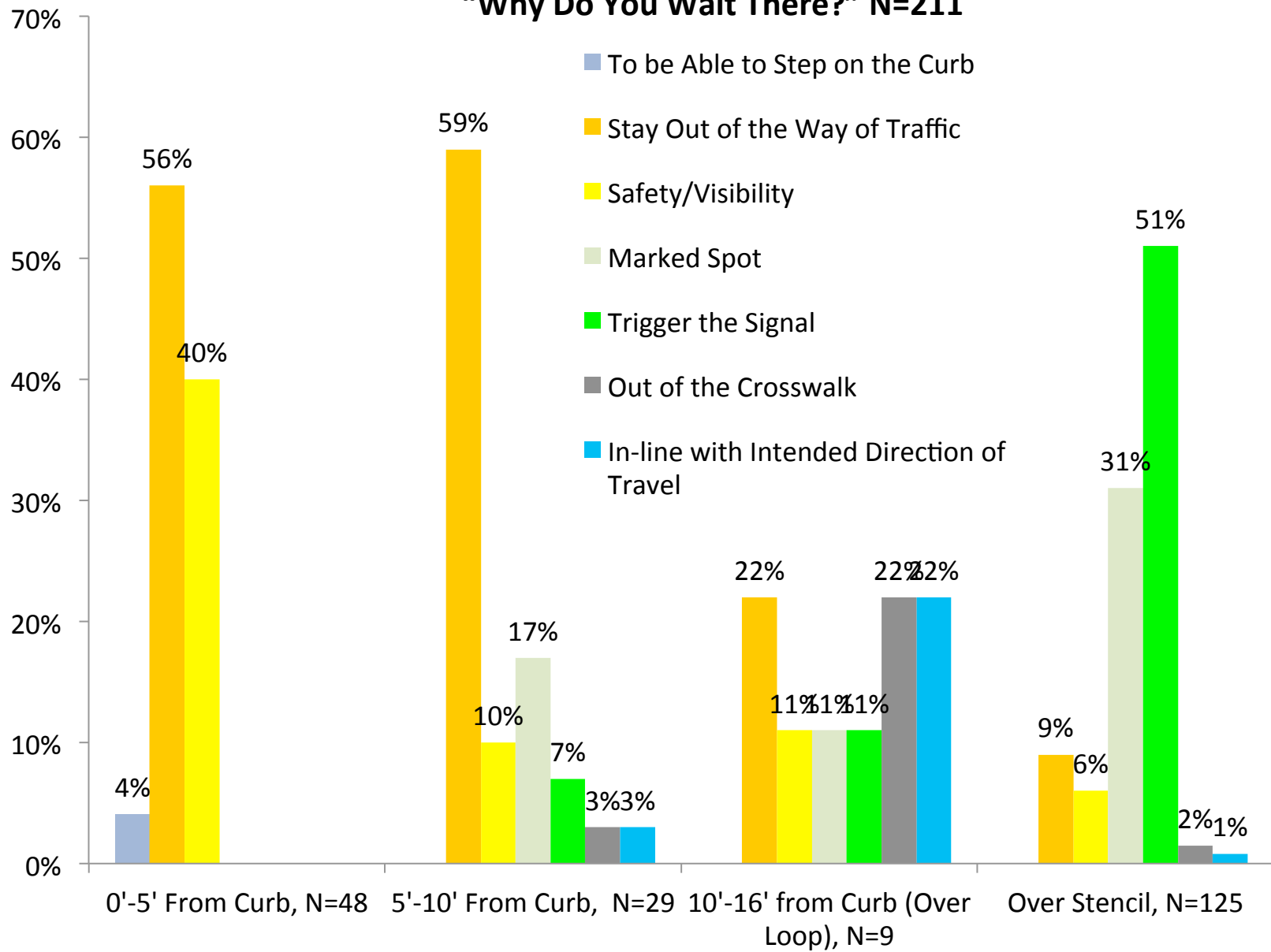


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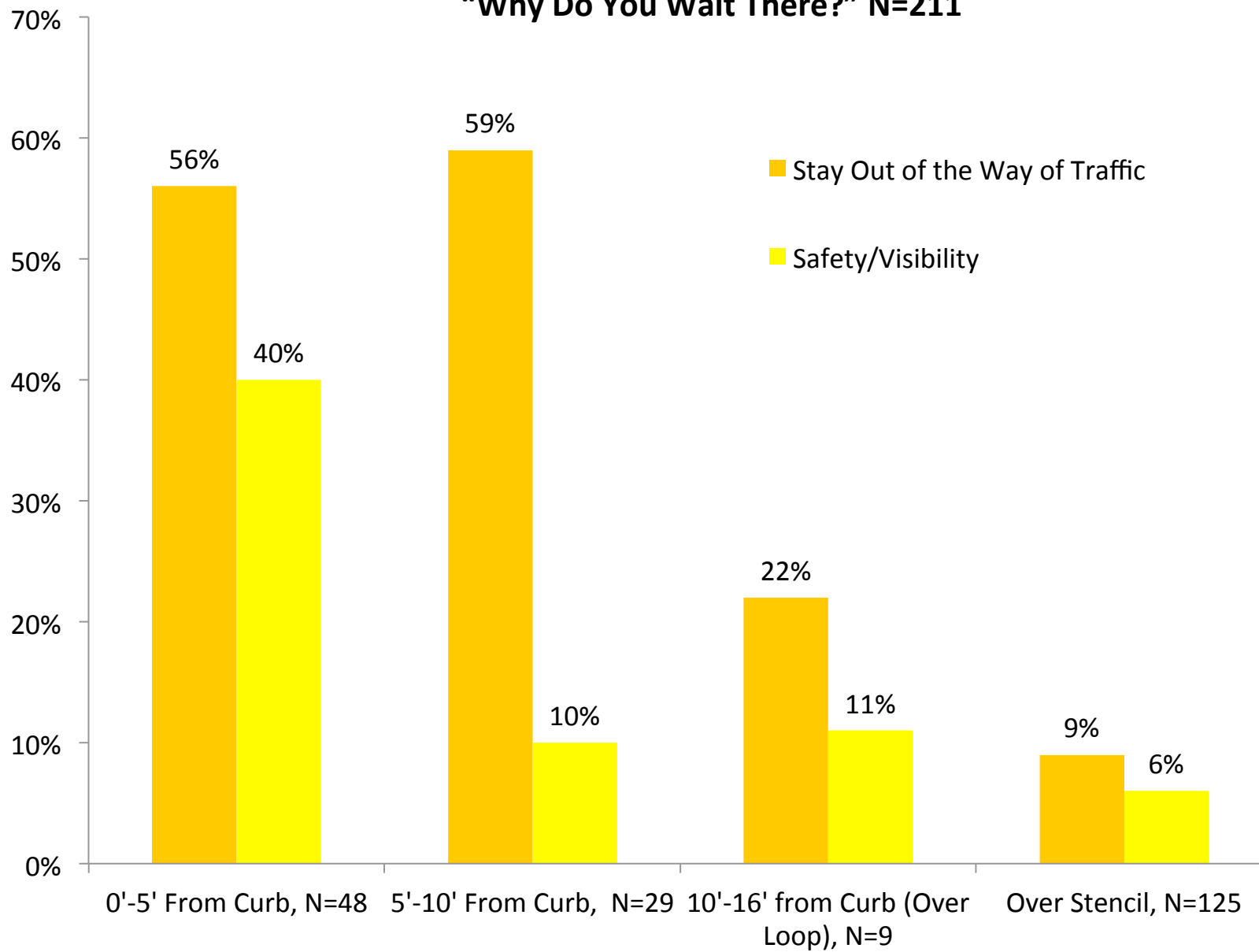
Survey – Results



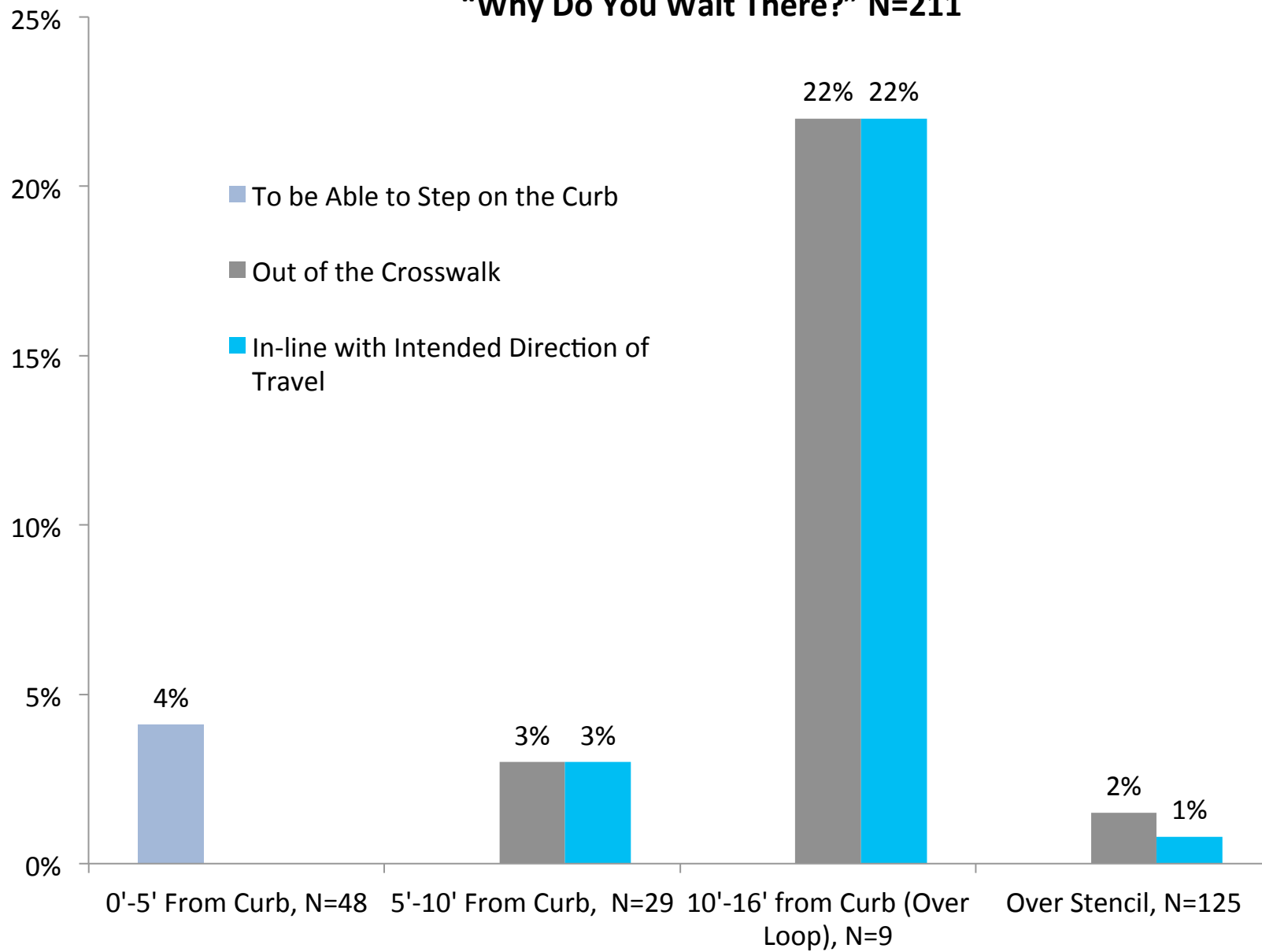
“Why Do You Wait There?” N=211



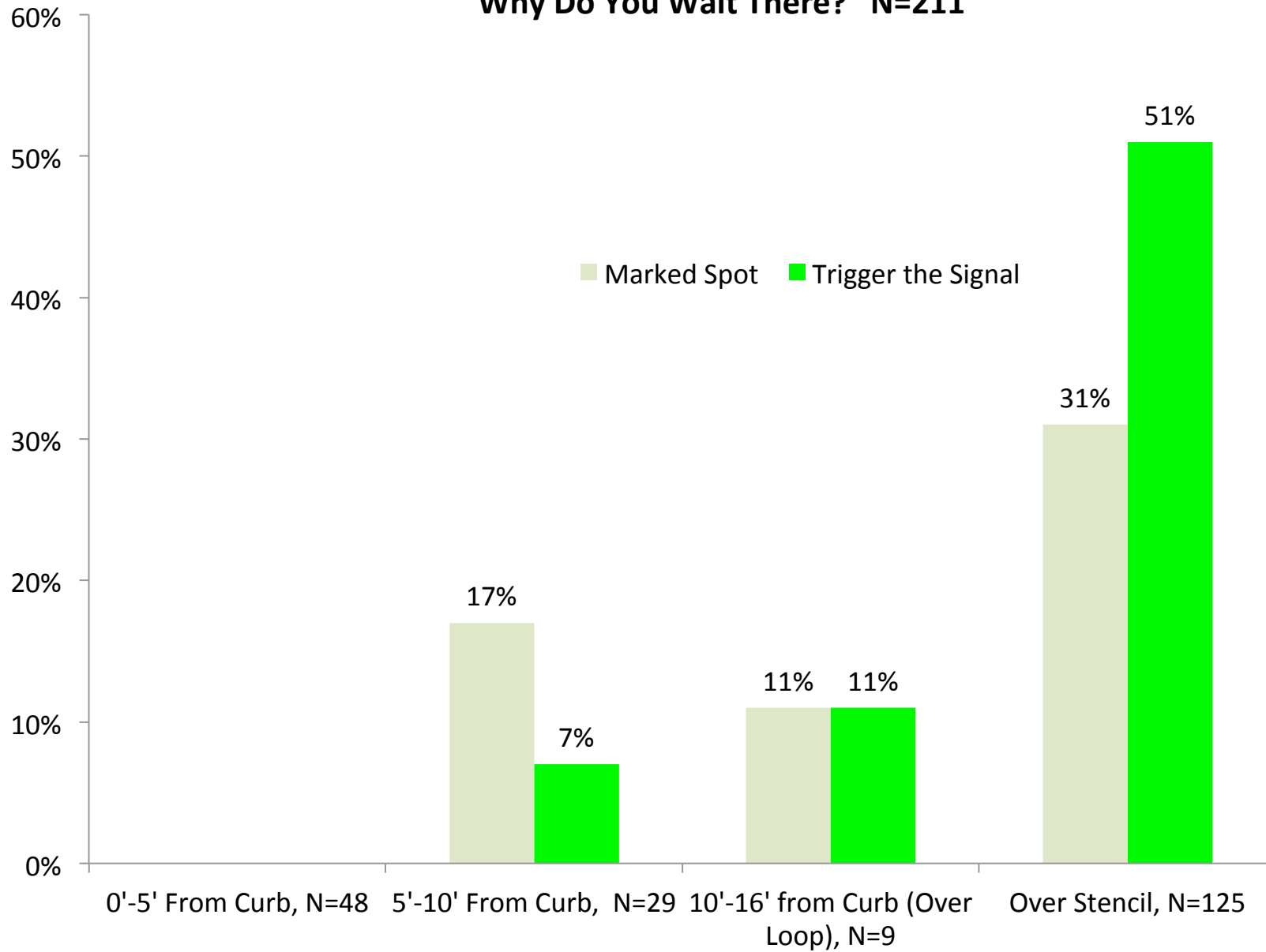
"Why Do You Wait There?" N=211



"Why Do You Wait There?" N=211



“Why Do You Wait There?” N=211



Survey – Results

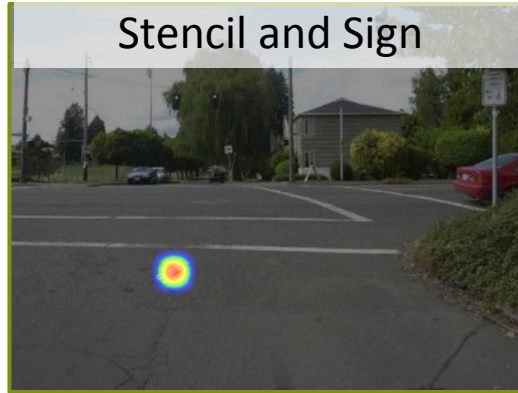
53.2%

Stencil Only



58.7%

Stencil and Sign



58.3%

“Green Backed” Stencil



No significant difference in queuing position between three test cases



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Survey – Results

- 45.4% - Wait Here to Trigger the Signal
- 33.9% - Bike Lane/Bike Route
- 11.5% - Recommended Waiting Location
- 6.5% - Don't Know or No Answer
- 1.8% - Bikes Allowed Here
- 0.9% - Other



“As a cyclist, what does the symbol in the above picture mean?”



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Video – Results

Analysis excludes observations in which:

- A vehicle arrives immediately after the cyclist
- The cyclist is riding with one or more other cyclists
- The cyclist violates the red indication
- The cyclist is riding on the sidewalk
- Other unusual circumstances



Video – Results

Table 1: Percent of Cyclists Waiting Over Loop Detector Before and After Marking(s) Installed



	Stencil $N_B = 51, N_A = 51$	Stencil and Sign $N_B = 92, N_A = 112$	“Green Backed” Stencil $N_B = 157, N_A = 225$
% Stopping Over Loop Before	27.5%	16.3%	46.5%
% Stopping Over Loop After	37.3%	44.6%	58.2%
χ^2	3.71	67.37	15.28
Degrees of Freedom	2	2	2
α	0.157	0.000	0.0005

N_B = Observations Before

N_A = Observations After



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Video – Results

Table 2: Percent of Cyclists Waiting Over Stencil Region Before and After Marking(s) Installed

(Only Includes Observations of Cyclists who Waited Over the Line)



	Stencil, $N_B = 14, N_A = 19$	Stencil and Sign $N_B = 15, N_A = 50$	“Green Backed” Stencil, $N_B = 73, N_A = 131$
% Stopping Over Stencil Region Before	42.9%	40.0%	50.7%
% Stopping Over Stencil Region After	62.3%	78.0%	83.2%
χ^2	3.20	30.08	55.43
Degrees of Freedom	1	1	1
α	0.074	0.000	0.000

N_B = Observations Before

N_A = Observations After



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Survey Results vs. Video Results



Survey Results

- Self reported preferences
- May represent a best case for stencil use
- Highlight the importance placed on safety



Video Results

Stencil with R10-22 sign and “Green Backed” stencil produce a significant effect

Limitations of Study



Designed
“Green Backed”
Stencil



Installed
“Green Backed”
Stencil

- Only one field test for each case
- Intersections not uniform in stripping configuration
- “Green Backed” stencil installed in field did not match original design
- High number of regular cyclist in Portland may skew results



What You Can Do



Sam Adams
Commissioner

Susan D. Kell
Director

Eileen Argentin
System Management

Don Gardner
Engineering & Development

Sam M. Irving, Jr.
Maintenance

Paul Smith
Planning

Vehicle Detection Or, Getting a Green Light on a Bicycle at an Intersection

How it's done at signalized intersections

In the city of Portland we use inductive loops (wires in the road) to detect traffic at signalized intersections whenever a traffic signal has been designed to respond to the presence of a few locations we use video cameras, like on the west end of the Broadway Bridge for westbound traffic and at N.E. 102nd and Fremont for eastbound traffic. However, we use inductive loops to detect traffic at most traffic-actuated signals.

A vehicle is detected when it passes over the inductive loop and the metal in the vehicle changes the magnetic field. The inductive loop is usually a six-foot diameter circle (usually 1.5 inches deep). These loops can also be in the shape of a diamond but in some cases circular loops are more economical to install. The wire between the loop and the controller is wound around itself to cancel false detection outside the desired detection zone.

There are a few locations where the loop is in the shape of a fifty-foot rectangle with a circle in the middle of the rectangle. These are called quadrapole loops and are usually in left-turn lanes. For economical reasons, when a quadrapole loop is replaced due to failure or road construction, we prefer to install four circle loops placed twelve feet center to center to achieve the same detection zone.

How we mark for bicycle detection

Whenever we receive a request to mark an approach for bicycle detection, our electricians test the loops. Once we verify a location where a loop consistently detects a bicycle, we paint the spot with a temporary white mark in the shape of two small arrows facing each other (Figure 3). Then we notify the good folks in the Pavement Markings Section and they install a permanent mark with hot plastic in the shape of a small bicycle (Figure 2) similar to

The PDX Reporter app interface on a smartphone. At the top is the City of Portland logo and the title 'PDX Reporter'. Below the title are two buttons: 'Photo Preview' and 'Select Photo'. Underneath these are two more buttons: 'Choose Report Type' and 'Set Report Location'. Below the buttons is a text input field labeled 'Add comments here...'. At the bottom are two buttons: 'Cancel' and 'Submit'. The status bar at the top shows the time as 2:08 PM and various icons for signal, Wi-Fi, and battery.

- Read about the City of Portland's Policy on bikes and detection: <http://www.portlandoregon.gov/transportation/article/145110>
- Call 503-823-SAFE or 823-CYCL
- Use the PDX Reporter App: <http://www.portlandoregon.gov/bts/article/419527>
- Share your knowledge!



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Acknowledgements



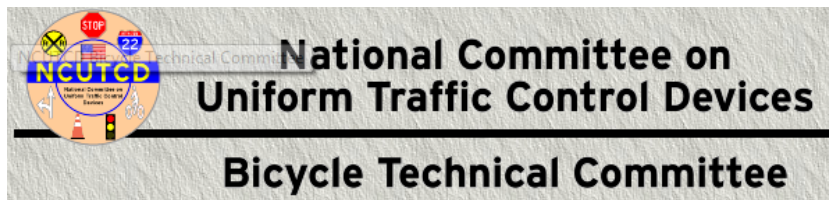
Rob Burchfield
Rodger Geller
Mark Haines



Steve Cohn



Ron Van Houten



Richard Moeur



Questions?



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Supplemental Slide – Installed Sign and Stencil



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Supplemental Slide – Installed “Green Backed” Stencil



Supplemental Slide – Site Selection

Quadrant	Intersection	Approach	Comments	Edge of Loop to Curb (estimated)	Thru Lane
N	Prescott St and MLK Blvd	WB	No stencil, loops visible. T intersection		10
NE	47th Ave and Sandy Blvd	NB	Stencil illegible and badly worn. Loops are visible.		10
N	Ainsworth St and MLK Blvd	WB	No stencil, loops visible		10
N	Vancouver Ave and Columbia Blvd	SB	No stencil, loops visible. Bike lane has no loop but extends to the stop bar.		10
SW	30th Ave and B-H Hwy	SB	No stencil, loops visible		10
N	Vancouver Ave and Rosa Parks Way	SB	No stencil, loops visible, bike lane with no loop. Push button nearby, no bike sign.		11
NE	47th Ave and Sandy Blvd	SB	No stencil, loops visible		11
SE	30th Ave and Hawthorne Blvd	NB	No stencil, loops visible		13
SE	27th Ave and Hawthorne Blvd	NB	No stencil, loops visible. Stencil on SB approach		13
SW	Sunset and Capitol Hwy	EB	No stencil, loops visible		13
SE	69th Ave and Powell Blvd	NB	No stencil, loops visible.		14
SE	69th Ave and Powell Blvd	SB	No stencil, loops visible.		14
N	Killingsworth St and MLK Blvd	WB	No stencil, loops visible	6	14
SE	52nd Ave and Powell Blvd	NB	No stencil, loops visible.	6	14
SE	112th Ave and Division St	NB	No stencil, loops visible	6	14
SE	52nd Ave and Flavel St	WB	No stencil, loops visible. T intersection		15
SE	30th Ave and Hawthorne Blvd	SB	No stencil, no loops visible		16
SW	35th Ave and Multnomah Blvd	NB	No stencil, loops visible. Stencil on SB approach	8	16



Supplemental Slide – Chi Squared Analysis

Chi Square Test of Proportions Using Filtered Observations, All Zones - 33rd and Grant (Alternative Stencil)						
Zone	Observations After	Observations Before	Percent of Observations After	Percent of Observations Before	Expected Value After	Chi Squared Value
1+2	65	65	28.9%	41.4%	93.2	8.51
3	131	73	58.2%	46.5%	104.6	6.65
4+5+6	29	19	12.9%	12.1%	27.2	0.12
	225	157	100.0%	100.0%		
						Total Chi Squared Value
						15.28
						α , df=2
						0.0005

Chi Square Test of Proportions Using Filtered Observations, Loop Zone Only - 33rd and Grant (Alternative Stencil)						
Zone	Observations After	Observations Before	Percent of Observations After	Percent of Observations Before	Expected Value After	Chi Squared Value
3.1	109	37	83.2%	50.7%	66.40	27.34
3.2+3.3	22	36	16.8%	49.3%	64.60	28.09
	131	73	100.0%	100.0%		
						Total Chi Squared Value
						55.43
						α , df=1
						0.00000



Supplemental Slide – Chi Squared Analysis

Chi Square Test of Proportions Using Filtered Observations, All Zones - Ainsworth and MLK (Stencil and Sign)						
Zone	Observations After	Observations Before	Percent of Observations After	Percent of Observations Before	Expected Value After	Chi Squared Value
1	51	68	45.5%	73.9%	82.8	12.20
2	50	15	44.6%	16.3%	18.3	55.17
4+5	11	9	9.8%	9.8%	11.0	0.00
	112	92	100.0%	100.0%		
					Total Chi Squared Value	67.37
					α , df=2	0.0000

Chi Square Test of Proportions Using Filtered Observations, Loop Zone Only - Ainsworth and MLK (Stencil and Sign)						
Zone	Observations After	Observations Before	Percent of Observations After	Percent of Observations Before	Expected Value After	Chi Squared Value
2.1	39	6	78.0%	40.0%	20.00	18.05
2.2+2.3	11	9	22.0%	60.0%	30.00	12.03
	50	15	100.0%	100.0%		
					Total Chi Squared Value	30.08
					α , df=1	4.13873E-08



Supplemental Slide – Chi Squared Analysis

Chi Square Test of Proportions Using Filtered Observations, All Zones - Dekum and MLK (Stencil Only)						
Zone	Observations After	Observations Before	Percent of Observations After	Percent of Observations Before	Expected Value After	Chi Squared Value
1+2	24	24	47.1%	47.1%	24.0	0.00
3	19	14	37.3%	27.5%	14.0	1.79
4+5+6	8	13	15.7%	25.5%	13.0	1.92
	51	51	100.0%	100.0%		
					Total Chi Squared Value	3.71
					α , df=2	0.157

Chi Square Test of Proportions Using Filtered Observations, Loop Zone Only - Dekum and MLK (Stencil Only)						
Zone	Observations After	Observations Before	Percent of Observations After	Percent of Observations Before	Expected Value After	Chi Squared Value
3.1	12	6	63.2%	42.9%	8.14	1.83
3.2+3.3	7	8	36.8%	57.1%	10.86	1.37
	19	14	100.0%	100.0%		
					Total Chi Squared Value	3.20
					α , df=1	0.074

